MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

PPH0105 – MODERN PHYSICS & THERMODYNAMICS
(Foundation in Engineering)

29 MAY 2019
2.30 p.m - 4.30 p.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 6 pages excluding the cover page and appendices with 5 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Figure Q1(a) shows the variation with time t of the displacement x of two progressive waves P and Q passing the same point. The speed of the waves is 20 cm/s.

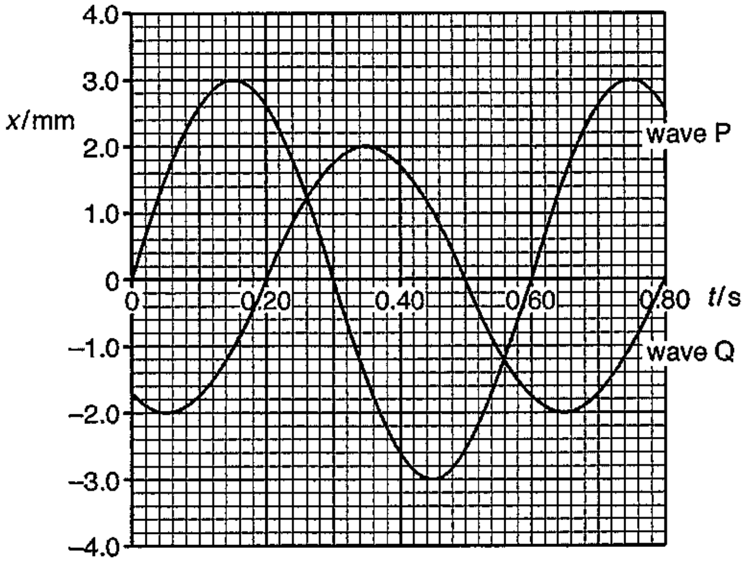

Figure Q1(a)

(i) Calculate the wavelength of the waves. [2 marks]

(ii) The two waves superpose as they pass the same point. Use Figure Q1(a) to determine the resultant displacement at time $t = 0.45$ s. [2 marks]

(iii) Determine whether waves P and Q can form a stationary wave. Explain. [1 mark]

(b) (i) State what is meant by the Doppler effect. [2 marks]

(ii) Figure Q1(b) shows a child sits on a rotating horizontal platform in a playground, moves with a constant 7.5 m/s, starts blowing a whistle at point P and stops blowing it at point Q on the circular path. The whistle emits sound of frequency 950 Hz. Describe the variation in the frequency of the sound heard by a distant observer. [3 marks]

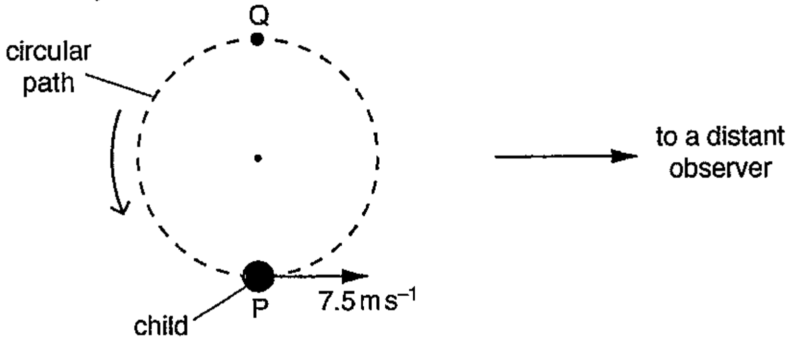

Figure Q1(b)

Continued...

Question 2

(a) Figure Q2(a) shows an optical fibre. XY is a ray of light passing along the fibre.

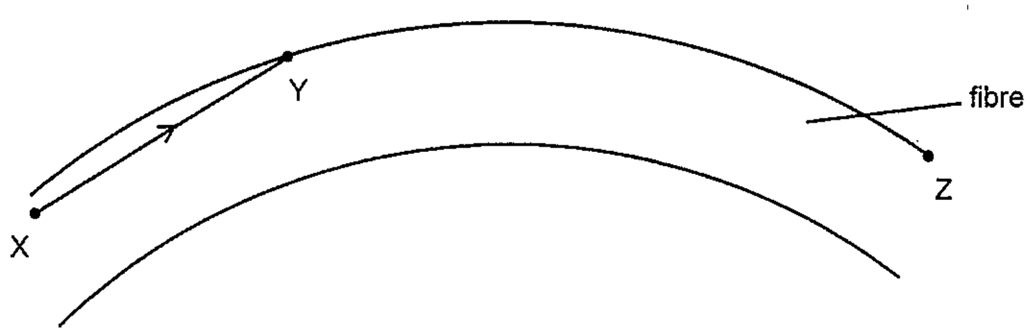

Figure Q2(a)

(i) Explain why the ray does not leave the fibre at Y. [1 mark]

(ii) The light in the optical fibre is travelling at a speed of 1.9×10^8 m/s. Calculate the refractive index of the material from which the fibre is made. [2 marks]

(b) Virtual images may be formed by both plane mirrors and by convex lenses. Figure Q2(b) shows a plane mirror and a convex lens.

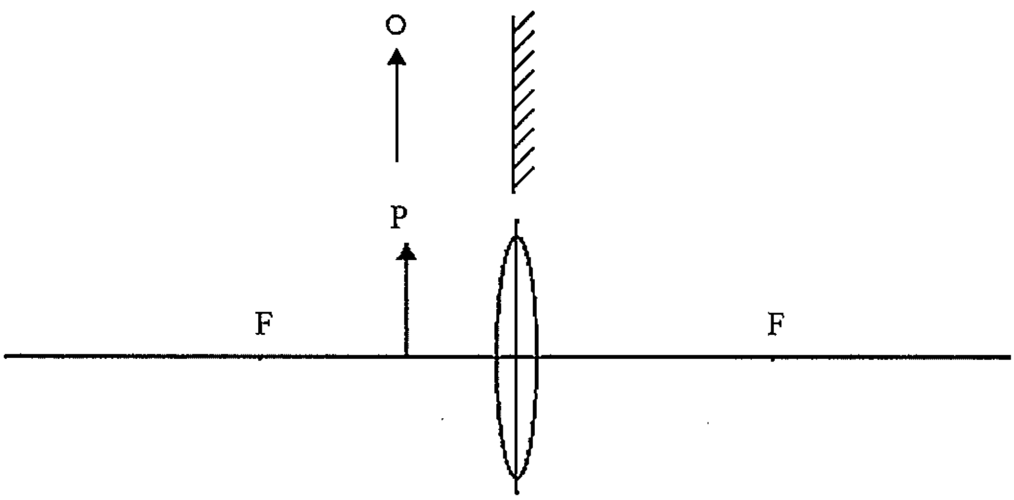

Figure Q2(b)

(i) Copy and draw rays to locate the approximate positions of the images of the tops of the two arrow objects O and P. [2 marks]

(ii) State one other similarity between the two images. [1 mark]

(iii) State one difference between the two images. [1 mark]

Continued...

(c) An arrangement for demonstrating the interference of light is shown in Figure Q2(c).

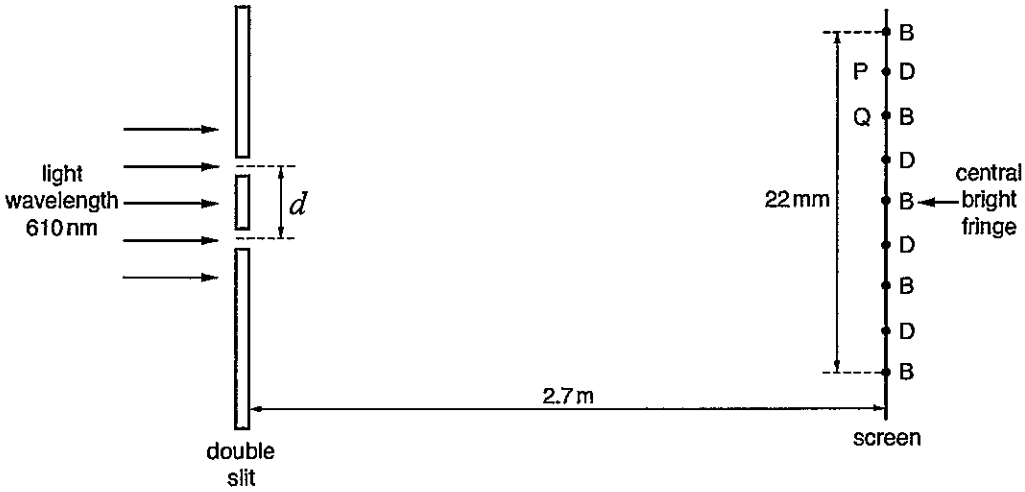

Figure Q2(c)

The wavelength of the light is 610 nm. The distance between the double slit and the screen is 2.7 m. An interference pattern of bright fringes and dark fringes is observed on the screen. The centres of the bright fringes are labelled B and centres of the dark fringes are labelled D. Point P is the centre of a particular dark fringe and point Q is the centre of a particular bright fringe, as shown in Figure Q2(c). The distance across five bright fringes is 22 mm.

(i) State the phase difference between the waves meeting at Q. [1 mark]

(ii) Determine the distance d between the two slits. [2 marks]

Continued...

Question 3

(a) (i) What is meant by photon in modern quantum theory of light? [1 mark]

(ii) Write the expression of energy for a photon. [1 mark]

(iii) Ultraviolet light is responsible for sun tanning. Find the wavelength of an ultraviolet photon whose energy is 6.4×10^{-19} J. [1.5 marks]

(b) (i) Experimental evidence that the light consists of photon comes from a phenomenon called the photoelectric effect. Explain the photoelectric effect. [1 mark]

(ii) Einstein applied the conservation of energy principle to form an equation to describe the photoelectric effect. Give and explain this equation. [1 mark]

(c) (i) Describe the concept of Wave-Particle Duality of Light proposed by de Broglie as a graduate student in 1923. [1 mark]

(ii) Determine the de Broglie wavelength for an electron moving at a speed of 1×10^7 cm/s in a semiconductor device. [1.5 marks]

(d) (i) The group of lines in visible region is known as the Balmer series in atomic hydrogen. The empirical equation for the observed wavelengths is $\frac{1}{\lambda} = R(\frac{1}{2^2} - \frac{1}{n^2})$, where R = Rydberg constant and n = 3, 4, 5, ... Find the longest wavelength of the Balmer series. [1 mark]

(ii) Name the series when n = 1 in line spectrum of atomic hydrogen. [1 mark]

Continued...

Question 4

(a) (i) In 1896, Henry Becquerel found that a uranium compound (uranyl potassium sulfate crystal) affected a photographic plate wrapped in light-proof paper. Name this process of spontaneous emission of radiation. [1 mark]

(ii) Identify the three common types of radiation that can be emitted by a radioactive substance. [1.5 marks]

(b) (i) Explain the activity of a radioactive sample. [1 mark]

(ii) Consider there are 3.0×10^7 radon atoms trapped in a car parking basement just after the basement is sealed against further entry of radon. Given the half-life of radon is 3.83 days.

(I) Determine the activity just after the basement is sealed against further entry of radon. [1.5 marks]

(II) How many radon atoms remain after 30 days? [1 mark]

(c) (i) Complete the radioactive decay series of $^{238}_{92}U$ below: [1 mark]

$$^{238}_{92}U \rightarrow {}^{234}_{\square}Th + {}^{\square}_{2}Y$$

(ii) Identify the element Y in part (i). [1 mark]

(d) (i) What is binding energy in a nucleus? [1 mark]

(ii) How to determine the binding energy of a nucleus? [1 mark]

Continued...

Question 5

(a) (i) What is Heat? [1 mark]

(ii) A healthy person has an oral temperature of 98.6 °F. Determine this temperature on the Celsius scale. [1 mark]

(b) (i) Two different objects receive different amounts of heat but experience the same increase in temperature. Give at least two possible reasons for this behavior. [2 marks]

(ii) Suppose 63.0 J of heat is added to a 128 g piece of aluminum at 25.0 °C. What is the final temperature of the aluminum? Specific heat capacity, $c = 900$ J/kg·K for aluminum. [2 marks]

(c) (i) What is the relation between absolute pressure and the number of molecules of an ideal gas? [1 mark]

(ii) In the morning, when the temperature is 288 K, David finds that the absolute pressure in his tires is 505 kPa. That afternoon he finds that the pressure in the tire has increased to 552 kPa. Find the afternoon temperature by ignoring expansion of the tires. [2 marks]

(d) State the First Law of Thermodynamics. [1 mark]

End of Page

Physical Constants

Acceleration due to gravity	g	=	9.8 m s^{-2}
Speed of Sound in Air	v	=	343 m s^{-1}
Speed of light in vacuum	c	=	$3 \times 10^{8} \text{ m s}^{-1}$
Threshold of hearing	I_0	=	$1.0 \times 10^{-12} \text{ W m}^{-2}$
Coulomb constant	k	=	$9.0 \times 10^{9} \text{ N m}^{2} \text{C}^{-2}$
Electronic charge	e	=	$1.602 \times 10^{-19} \text{ C}$
Electron mass	m_e	=	$9.1 \times 10^{-31} \text{ kg}$
Proton mass	m_p	=	$1.6726 \times 10^{-27} \text{ kg}$
Neutron mass	m_n	=	$1.6749 \times 10^{-27} \text{ kg}$
Refractive index of air/vacuum	n	=	1.0
Wein's displacement constant		=	$0.2898 \times 10^{-2} \text{ m.K}$
Planck's constant	h	=	$6.63 \times 10^{-34} \text{ J. s}$
Rydberg constant	R_H	=	$1.097 \times 10^{7} \text{ m}^{-1}$
Avogadro's Number	N_A	=	$6.02 \times 10^{23} \text{ mol}^{-1}$
Unified atomic mass unit	1 u	=	$1.66 \times 10^{-27} \text{ kg}$
	1 eV	=	$1.602 \times 10^{-19} \text{ J}$
Threshold of intensity of hearing	I_0	=	$1.0 \times 10^{-12} \text{ Wm}^{-2}$
Stefan-Boltzmann constant	σ	=	$5.67 \times 10^{-8} \text{ J s}^{-1}.\text{m}^{-2}.\text{K}^{-4}$
Universal gas constant	R	=	$8.31 \text{ J mol}^{-1} . \text{K}^{-1}$
Boltzmann's constant	κ	=	$1.38 \times 10^{-23} \text{ J K}^{-1}$
	1 atm	=	$1.013 \times 10^{5} \text{ Pa}$

The energy equivalent of the atomic mass unit is 931.5 MeV

Formula List

$\sin\theta_1 + \sin\theta_2 = 2\sin\frac{1}{2}(\theta_1+\theta_2)\cos\frac{1}{2}(\theta_1-\theta_2)$

$\cos\theta_1 + \cos\theta_2 = 2\cos\frac{1}{2}(\theta_1+\theta_2)\cos\frac{1}{2}(\theta_1-\theta_2)$

$\sin\left(\theta+\frac{\pi}{2}\right) = \cos\theta$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angle

$D(x,t) = D_M \sin(kx \pm \omega t \pm \phi)$

$v = \sqrt{\frac{F_\tau}{\mu}}$ $\quad$ $v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}}$

$\lambda_n = \frac{2}{n}L$ $\quad$ $f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$

$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $\quad$ $\frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\}$

$d\sin\theta = m\lambda$ $\quad$ $d\sin\theta = \left(m+\frac{1}{2}\right)\lambda$

$\lambda_m . T = 0.2898 \times 10^{-2}$ $\quad$ $I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$

$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right)$ $\quad$ $r_n = \frac{\hbar^2}{mke^2}n^2$ $\quad$ $L = mvr_n$

$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$ $\quad$ $\frac{1}{\lambda} = \frac{mk^2Z^2e^4}{4\pi\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ $\quad$ $\lambda = \frac{h}{p}$

$R = R_0 e^{-\lambda t}$ $\quad$ $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$ $\quad$ $Q = (M_X - M_Y - M_\alpha)c^2$

$pV = nRT$ $\quad$ $k = \frac{R}{N_A}$

$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L}$ $\quad$ $\frac{\Delta Q}{\Delta t} = e\sigma AT^4$ $\quad$ $\frac{\Delta Q}{\Delta t} = IeA\cos\theta$

$\overline{\text{KE}} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT$ $\quad$ $U = \frac{3}{2}nRT$

$Q = \Delta U + W$ $\quad$ $W = \int dW = \int_{V_i}^{V_f} P\,dV$